Directorate of Intelligence

Top Secret

25X1

The Outlook for Soviet Oil Drilling in the 1980s

25X1

25X1

A Research Paper

Top Secret

SOV 84-10089CX

June 1984

25X1

Copy 407

Directorate of
Intelligence

Top Secret

25X1

The Outlook for Soviet Oil Drilling in the 1980s

25X1

A Research Paper

This paper was prepared by
Office of Soviet Analysis, with contributions from
and from the Petroleum Resources Branch, Office of Global Issues. Comments and queries are welcome and may be addressed to the Chief, Soviet Economy Division, SOVA,

25X1
25X1
25X1
25X1

Top Secret
SOV 84-10089CX
June 1984

25X1
25X1

25X1

The Outlook for Soviet Oil Drilling in the 1980s

25X1

Key Judgments

Information available as of 1 May 1984 was used in this report.

Drilling for oil will rise rapidly during the remainder of the 1980s, as the Soviets make a major effort to keep oil production stable. This rise will push up the USSR's energy investment requirements and tie up scarce manpower and equipment.

25X1

The oil industry must expand its *exploration* drilling rapidly, to find new formations before the ones currently producing play out. It must also increase its *development* drilling, to offset declines in production from existing wells and to exploit recent finds. These new formations have generally been deeper and less productive than those they replace and therefore require more drilling outlays.

25X1

We believe that in 1990 the oil ministry will drill some 35-50 million meters, for exploration and development combined. This will require a herculean effort—it is far above the nearly 26 million meters drilled in 1983—but even so it probably will not sustain oil production at the 1983 level of 12.3 million barrels per day (b/d).

25X1

The Soviets themselves suggest that maintaining production at the 1983 rate would require drilling to double every five years—to some 60-70 million meters in 1990. Even though drilling probably will become more efficient in 1984-90, the additional labor and capital equipment required to drill and maintain 60 million meters of new well would still be too great for Moscow to muster in a period of slow growth in labor force and investment. Besides, oil production involves more than drilling. The Soviets are currently having trouble managing their existing well stock—let alone the 8,000 to 9,000 new wells being added every year. Production problems may become overwhelming as drilling is accelerated.

25X1

Our drilling estimate is based on an assessment of drilling efficiency and of labor and capital availability in the 1980s. Specifically:

- We estimate that drilling productivity (measured by meters drilled per drilling brigade per year) will increase by more than one-third between 1982 and 1990. This projected improvement reflects better equipment and techniques, improved infrastructure in the key oil-producing region of West Siberia, and an increased proportion of total drilling being done in West Siberia—where productivity is generally higher than in other areas.

- Even with productivity gains, the Soviets will need to increase the number of drillers. We estimate that the oil ministry will add 20 to 60 drilling brigades annually in the period to 1990.

25X1

25X1

25X1

- Investment outlays for drilling probably will rise faster than drilling meterage because of increasing drilling costs. We estimate—on the basis of rising drilling requirements and costs—that oil industry capital investment will be about 20 billion rubles in 1990, more than double the level in 1982.

25X1

The Soviets' chances of keeping oil production close to 12 million b/d through 1990 will depend heavily on development drilling, and especially its distribution between West Siberia and other regions. In recent years the Soviets have made substantial gains by shifting drilling teams from older regions into West Siberia. We expect them to continue to add resources there, although the payoff for increases is becoming smaller each year. Drilling in other regions, where oil output is declining, is likely to level off for the rest of the decade.

25X1

The USSR produces most of its own drilling equipment, but it relies on imports to fill some specific needs. In some respects, Soviet drilling technology is 10 or more years behind that employed in the West. We anticipate that the Soviets will continue to seek selected types of Western drilling technology.

25X1

Exploration drilling, principally for oil, is scheduled to average more than 10 million meters per year in 1986-90, about two-thirds more than in 1983. This increase appears to reflect a desire to compensate for recent neglect of exploration. Even though it will remain small compared with development drilling, this planned increase in exploration drilling will require a substantial increase in skilled labor and equipment.

25X1

The most promising areas for exploration are offshore. Such areas currently provide less than 2 percent of total output, but the Soviets plan to accelerate their offshore drilling activity, concentrating on the Caspian Sea, offshore Sakhalin, and the Barents Sea. Access to Western offshore technology has been and will continue to be instrumental to Soviet offshore drilling and production.

25X1

The oil ministry will also be competing with the gas ministry for drilling resources. The gas ministry currently drills less than 10 percent as much as the oil ministry, and gas drilling requirements are expected to grow more slowly than oil drilling needs. Nevertheless, gas drilling is usually more expensive and slower than drilling for oil—principally because of greater depths and pressures—and expanded gas production is critical to Soviet energy plans for the rest of the decade and beyond.

25X1

25X1
25X1

25X1

Contents

[redacted] 25X1

Figures

Tables

[redacted] 25X1
25X1

25X1

The Outlook for Soviet Oil Drilling in the 1980s

25X1

Introduction

Drilling—a key determinant of current and future oil production—has two basic functions. *Exploratory drilling* seeks to discover new fields and determine their extent; it provides the basis for estimating reserves and planning future production. *Development drilling* is critical to current production, which requires wells for oil production and for water injection.

Three ministries are responsible for oil drilling—the Ministries of Geology, of the Petroleum Industry, and of the Gas Industry (table 1).[1] All three drill exploration wells, but only the two industrial ministries do development drilling. The Ministry of Geology is responsible for assessing potential resources (for example, the oil and gas potential of a geologic basin) and for initially locating oil and gas fields.[2] The subsequent detailed assessment of oilfield size and potential and the drilling of development wells normally are handled by the oil ministry.

Some variations from this general pattern occur. For example, the oil ministry focuses on exploration drilling in established producing regions, while the Ministry of Geology handles nearly all of the exploration drilling, including field delineation, in West Siberia and other less-explored areas. Drilling procedures and organization are discussed further in appendix A.

All drilling, whether for exploration or development and whether for oil, gas, or water, requires basically the same equipment (with some variations due to differences in environment, depth, and geology) and labor skills. Drilling is measured in million meters per year in the USSR. To the extent that labor and equipment are mobile, drilling by any ministry can be redirected; for example, gas ministry crews and equipment could be used to drill for oil. The oil ministry, which accounted for 43 percent of exploratory drilling and 93 percent of development drilling in 1980, is the primary focus of this study.

Table 1
USSR: Organization of Oil and Gas Exploration and Production

Function	Ministry
Converting resources to reserves	
Geologic mapping	Geology
Seismic surveying	Geology
Exploration drilling	Geology, oil, and gas
Converting reserves to production	
Drilling new wells	Oil and gas
Fluid-lift efforts	Oil and gas
Water injection	Oil and gas
Enhanced oil recovery	Oil and gas

Note: Roughly 3 percent of Soviet oil output is handled by the gas ministry, which controls all offshore oil and gas production and also produces gas liquids from gasfields. The oil ministry accounts for roughly 5 percent of Soviet gas output.

25X1

25X1

25X1

25X1

Since 1965, Soviet oil drilling has more than tripled, with the largest gains occurring in the late 1970s (figure 1). Between 1965 and 1980, all of the growth occurred in development drilling, and exploration drilling declined. Plans for 1981-85 call for even more rapid growth in development drilling, plus a substantial increase in exploration drilling.

25X1

25X1

The oil ministry's drilling target for 1985 is 30.5 million meters—up nearly 70 percent over 1980. Past trends in oil production and drilling, together with the

25X1

25X1

25X1

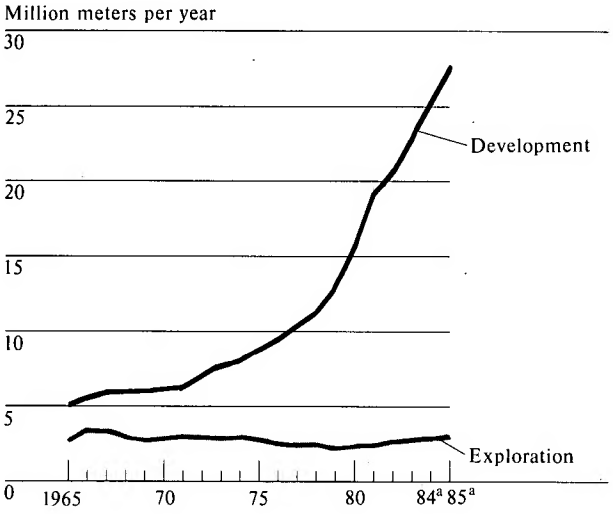
[1] The gas ministry is responsible for all offshore production and exploration—both oil and gas.

[2] In addition to oil and gas exploration, the geology ministry performs shallower drilling for mineral deposits of all types. It has also drilled several very deep wells (for example, an 11,000-meter well on the Kola Peninsula) to study the earth's crust and upper mantle. The Ministries of the Petroleum and Gas Industries are commonly called the oil and gas ministries.

25X1

25X1

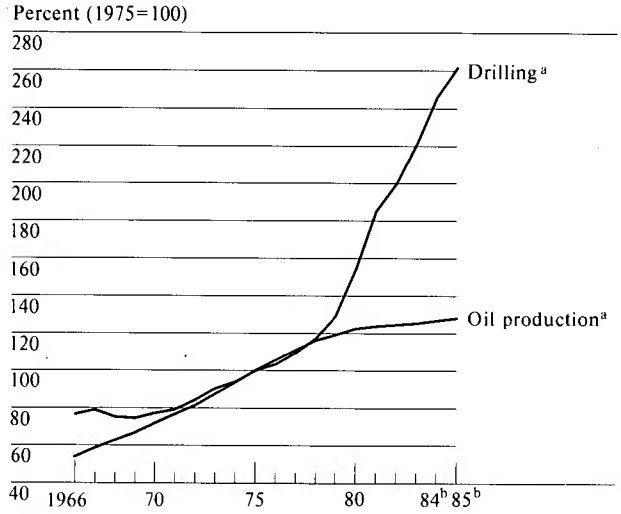
Figure 1
USSR: Oil Ministry Drilling, 1965-85



[a] Planned.

302951 6-84

Figure 2
USSR: Oil Production and Drilling, 1966-85



[a] Drilling figures are for the USSR Ministry of Petroleum only; production is the USSR total.
[b] Planned.

302952 6-84

25X1

25X1

plan projections, are shown in figure 2. Clearly, the Soviets face sharply higher drilling requirements in their pursuit of small production gains. Drilling will have to increase still further after 1985.

- The Soviets clearly intend to reverse this trend According to a Soviet periodical, a 29-percent increase in total exploration drilling is planned for 1981-85 and a 47-percent increase for 1986-90 [1].

25X1
25X1

Exploration Drilling

Exploration wells are the final step in the exploration process. The preliminary steps—regional and local geologic and geophysical studies and shallow structural and deep "parametric" drilling—determine that an exploration well should be drilled in a specific location.

The exploration drilling of the oil, gas, and geology ministries (summarized in table 2) illustrates several noteworthy trends:

- Exploration drilling stagnated in the 1970s—a period in which oil production and development drilling rose dramatically. The large drop in drilling by the oil ministry was offset by gains by the other two ministries.

Regional Trends

The amount of exploration drilling varies widely among regions Its most striking feature is the heavy emphasis still being given to exploration in the older producing areas where output is declining, such as the Volga-Urals, North Caucasus, and Central Asia. West Siberia was the principal growth region of the 1976-80 period, but it accounted for only 12 percent of exploration drilling in 1971-75 and 17 percent in 1976-80. The Volga-Urals region, where oil production peaked at 4.5 million b/d in 1975 and declined to about 3.8 million b/d in 1980, still received 31 percent of Soviet exploration drilling in 1971-75 and an estimated 28 percent in 1976-80.

25X1
25X1
25X1

25X1

25X1

Exploration Drilling Procedures

*Deep exploration wells are of two basic types—prospecting (*poiskovaya*) and exploratory (*razvedochnaya*). Prospecting wells are comparable to "wildcat" wells in the West—drilling in a structure for the first time to search for oil or gas. Exploratory wells are step-out wells drilled to determine the extent of a previous discovery. The two types are usually reported in Soviet data as a single category. In 1977, however, a Soviet monograph stated that prospecting drilling was 58.5 percent of total exploration drilling, and exploratory drilling 34.7 percent. The remaining 6.8 percent of deep exploration drilling consisted of "parametric" or test wells drilled to learn more about the general geology of a region [2].*

25X1

Three factors largely determine the amount of exploration drilling planned in any country. These are the reserve-to-production ratio, finding rates, and average depths of new prospects. Planners know they must have some minimum level of reserves if they are to sustain a given production rate. In theory, a production rate may be determined first; then the additions to reserves required to support this level are determined. Then exploration drilling targets (in meters) are set, on the basis of expected finding rates—that is, the amount of reserves the oil and gas experts expect to discover per meter drilled in any given region.

25X1

Soviet press articles since the late 1970s have scored the earlier neglect of exploration in West Siberia [3]. Plans for the amount of new reserves to be discovered in West Siberia were unfulfilled for the first time in 1976 and for the second time in 1977 [4]. Currently, the Soviets are attempting to boost drilling rapidly. After stagnating in the early and middle 1970s at 500,000 to 600,000 meters annually, exploration drilling in West Siberia surpassed 1 million meters in 1980. Plans for 1981-85 originally called for exploration drilling there to average nearly 2.5 million meters per year, but in 1981-83 it averaged only about 1.4 million meters, according to a Soviet publication [5].

25X1

Plans for 1981-85 also call for substantial, but smaller, growth in exploration drilling outside West Siberia. The Soviets plan increases of 20 percent in Kazakhstan, 140 percent in East Siberia, 80 percent in Komi, and 30 percent in the Volga-Urals region [6].

25X1

25X1

The relatively limited amount of exploration drilling in West Siberia appears the more surprising in light of the remarkable effectiveness of exploration there (table 3). For each meter drilled, exploration drillers found four times as much oil in West Siberia as in the nation as a whole, and drilling costs per ton of reserves were only 23 percent of the national level—but only 17 percent of total exploration drilling was done there in the last half of the 1970s.

25X1

This neglect of exploration came at a time of accelerating production. West Siberia accounted for all growth in Soviet oil production in 1976-80, besides

25X1

25X1

25X1

Table 2
USSR: Exploration Drilling, 1961-90

Thousand meters

	1961-65 [a]	1966-70 [a]	1971-75 [a]	1976-80	Plan	
					1981-85	1986-90
Total	**24,661**	**26,226**	**26,123**	**26,700** [b]	**34,400** [b]	**50,700** [b]
Oil ministry	16,342	15,380	14,532	11,750 [c]	13,000 [c]	NA
Gas ministry	36	135	876	2,400 [c]	3,200 [c]	NA
Geology ministry	8,263	10,711	10,715	12,550 [c]	18,200 [c]	NA

[a] M. M. Brenner, *Ekonomika geologorazvedochnykh rabot na neft' i gaz v SSSR* (Moscow, Nedra, 1979).
[b] *Ekonomicheskaya gazeta,* No. 5, January 1983, p. 1.
[c] Estimates based on plans and several Soviet press reports.

25X1

offsetting more than 1 million b/d of production decline elsewhere. The Soviets clearly were aware of the imbalance. Academician A. A. Trofimuk stated in 1980 that exploration drilling was 20 times as effective in West Siberia as elsewhere [7].

The limited exploration effort in West Siberia is an inefficient allocation of drilling resources, judged by Western standards, and can be attributed in large measure to the following factors:

- West Siberia has a harsh environment and limited infrastructure. The inability of the region's economy to support a greatly expanded exploration effort has hindered the drilling effort. Evidence of infrastructural constraints appears frequently in the Soviet press, in complaints that roads, electric power, and freight capacities are inadequate and living conditions are poor [8].[3] (The infrastructure problem is discussed more fully in appendix B.)

[3] The importance of infrastructure for operations is illustrated by the Soviets' vow not to repeat "the mistake of Povkh"—referring to a field (Povkhovsk) north of Nizhnevartovsk where drilling began before the roads and other logistic support were established and, as a result, substantial delays were incurred [9].

- The relatively small West Siberian exploration drilling effort apparently reflected optimism arising from the great discoveries in the 1960s and early 1970s. The size and quality of these finds were such that reserve plans were met even when drilling plans were missed [10]. Efforts to increase exploration drilling in the late 1970s fell short of plans.

25X1
25X1

- Labor, materials, and plant and equipment are not as mobile in the USSR as in the West and cannot easily be transferred from an old production area to a new one. Even though production costs are rising in the Volga-Urals and Azerbaijan, the Soviets would probably go to great lengths to prevent large regional shifts in labor and capital assets, such as would be caused by the collapse of the oil industry there. But as oil regions mature, new well flows and exploration finding rates generally fall. As a result, drilling for both exploration and development must increase, if only to moderate the decline in production. This problem partially explains why Soviet planners allocate high levels of exploration to older regions.

25X1

25X1

25X1

Table 3
USSR: Effectiveness of Exploration Drilling, by Region, 1976-80

	Volume of Exploration Drilling (*percent of USSR total*)	Oil Discovered per Meter Drilled (*percent of USSR average*)	Discovery Cost per Ton of Reserves (*percent of USSR average*)
West Siberia	17	406	23
European areas	67	38	250
Central Asia and Kazakh SSR	13	44	276
East Siberia and Far East	3	35	487

Source: A. P. Krylov, et. al., *Modelirovaniye razvitiya i razmeshcheniya neftyanoy promyshlennosti* (Moscow, Nedra, 1981), p. 16. (Note: Krylov's table apparently refers to exploration drilling for oil only—not for gas.)

25X1

Development Drilling

The Soviets have been adding roughly 2 million b/d of new oil production capacity annually in recent years. About 95 percent of this is required to offset declining production from existing wells [11]. In other words, if they added no new wells, production would decline by 1.5-2.0 million b/d in one year. They can add some new capacity by reopening inactive wells, installing larger pumps, and other techniques, but new wells are the principal source of new capacity.[4]

Drilling in the 1970s and Plans for 1981-85

Table 4 summarizes the amount of drilling planned for and actually done by the oil ministry. Generally, overall drilling plans were met or almost met in the early and middle 1970s. Exploration drilling gradually declined until 1979, before beginning to rise slowly, while development drilling grew rapidly, especially after 1979. The rise in development drilling reflects three production problems: increasing depletion rates, increasing well depths, and declining new-well flows.

25X1

Development drilling increased by 76 percent between 1975 and 1980, and this increase was a major factor in the 23-percent growth of oil production that occurred in that period. Nevertheless, during 1976-80 as a whole the oil ministry fell short (by over 3.3 million meters) of its plan to drill a total of 75 million meters. This shortfall was presumably one of the factors in the planners' downward revision of their 1980 oil production target from 12.4-12.8 million b/d to 12.1 million b/d.

25X1

25X1

The mid-to-late 1970s saw sharp declines in the ratio between net growth in total oil production and meterage drilled for development (figure 4), and the ratio will continue to slide in the 1980s. The decline reflects three factors:

- Most of the production from new wells simply offsets production losses from depletion of older wells. The share of new capacity required to offset depletion has climbed from 66 percent in 1971-75 to a planned 95 percent in 1981-85 [12].

25X1
25X1

[4] The amount of development drilling called for in a plan is based on the amount of new production capacity the industry will require if it is to achieve the planned growth in output. Planners must specify the number of meters to be drilled, which they determine principally by estimating what the average flow rates and depths of new wells will be; they also estimate how many additional wells must be drilled so that water can be injected to increase the flow.

25X1

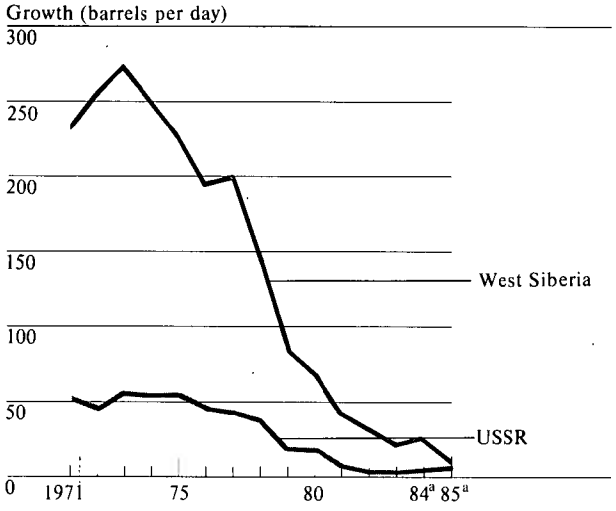
Table 4 *Million meters*
USSR: Oil Ministry Exploration and Development Drilling, 1970-85

	Planned Total	Actual		
		Total	Exploration	Development
1970	NA	9.0	2.8	6.2
1971	9.8	9.2	2.9	6.3
1972	9.7	9.8	2.9	6.9
1973	10.2	10.6	2.9	7.7
1974	12.5	11.0	2.9	8.1
1975	12.0	11.6	2.7	8.9
1976	12.0	12.1	2.6	9.5
1977	NA	12.8	2.4	10.4
1978	14.3	13.7	2.4	11.3
1979	16.9	15.1	2.2	12.9
1980	19.3	18.0	2.3	15.7
1981	22.8	21.6	2.4	19.2
1982	24.4	23.3	2.5	20.8
1983	26.7	25.8	2.7	23.1
1985 Plan	30.5 [a]		3.0 [a]	27.5 [a]

[a] The 1985 plan of 30.5 million meters was published at the end of 1982. The division between exploration and development drilling is a CIA estimate based on cumulative 1981-85 exploration and development drilling goals and the 1985 drilling plan for West Siberia.

Sources: Numerous Soviet press and oil industry publications.

Figure 4
USSR: Net Growth in Oil Production per 1,000 Meters of Oil Ministry Drilling, 1971-85



[a] Planned.

302954 6-84

25X1

- The average flow rate of new wells is dropping sharply, especially in West Siberia (figure 8). This requires more new wells—hence more drilling meterage—to provide a given amount of new capacity.

- The average depth of new wells is increasing (table 5). This trend requires more drilling meterage to complete a given number of wells.

The impact of drilling shortfalls on oil production is a complicated question, however, because drilling is not the only determining factor in production. In older fields, for example, the use of larger or more efficient pumps can partially compensate for the drilling of fewer new wells. The area in which specific drilling shortfalls occur is also significant. Shortfalls in West Siberia occur primarily in the fields that are hardest to supply. In other regions, drilling probably will be concentrated in more productive areas, and the shortfalls will be concentrated in marginal areas; this will tend to minimize the impact of these drilling shortfalls on aggregate oil production.

25X1

25X1

25X1

Regional Trends

Since the mid-1970s, Soviet development drilling has increased primarily in West Siberia and has stagnated or grown slowly in other regions. In the Komi, Udmurt, and offshore areas, the amount of drilling has grown but is still relatively small. (Drilling in West Siberia is further discussed in appendix B and offshore development in appendix D.)

25X1

25X1

25X1

The increase in West Siberia was paralleled by absolute declines in drilling outside West Siberia in 1978 and 1979, reflecting the transfer of drilling

25X1

Table 5 *Meters*
USSR: Average Depth of Oil Ministry Development Wells, 1965-85

	USSR	West Siberia
1965	1,649 [a]	1,724 [b]
1966	1,655 [a]	1,841 [b]
1967	1,686 [a]	1,931 [c]
1968	1,691 [d]	2,060 [c]
1969	1,714 [d]	2,088 [c]
1970	1,772 [d]	2,106 [b]
1971	1,786 [d]	NA
1972	1,773 [d]	NA
1973	1,775 [d]	2,236 [b]
1974	1,811 [d]	2,246 [b]
1975	1,832 [d]	2,252 [g]
1976	1,887 [d]	NA
1977	NA	NA
1978	1,994 [e]	NA
1979	NA	NA
1980	2,078 [f]	2,400 [g]
Planned, 1981-85	2,360 [h]	2,600 [h]

[a] *Bureniye*, No. 6, June 1973, pp. 5-11.
[b] N. A. Grigoryan and V. S. Grigoryan, *Ekonomika bureniya naklonnykh skvazhin* (Moscow, Nedra, 1977), p. 86.
[c] A. R. Orlov and I. D. Karyagin, *Sovershenstvovaniye organizatsii proizvodstva burovykh rabot v Zapadnoy Sibiri* (Moscow, Nedra, 1980), p. 31.
[d] *Bureniye*, No. 9, September 1977, p. 4.
[e] R. Sh. Mingareyev, et al., *Tekhnicheskiy progress v neftyanoy promysh'lennosti v desyatoy pyatiletke* (Moscow, Nedra, 1981), p. 25.
[f] *Neftyanik*, No. 1, January 1981, p. 21.
[g] *Neftyanoye khozyaystvo*, No. 11, November 1982, p. 18.
[h] Based on 1981-85 plans, as cited in *Ekonomicheskaya gazeta*, No. 5, January 1982, p. 2, and *Neftyanoye khozyaystvo*, No. 1, January 1981, p. 4.

25X1

resources from European areas of the USSR to West Siberia. The downward trend of development drilling in other regions was reversed dramatically, with gains of 20 percent in 1980 and 15 percent in 1981, according to Soviet data, but the gains did not continue after 1982. Despite the growing emphasis on West Siberia, the oil ministry plans that in 1985 more than 70 percent of its oil wells will be in other regions (figure 6).

25X1

25X1

Labor and Investment Trends

In current Soviet planning, the increased drilling meterage scheduled for 1981-85 is to come principally from greater efficiency in the use of drilling manpower and equipment. This expectation is implicit in the plan, even though the record shows that meterage increases in West Siberia through 1981 were achieved primarily through the use of increased inputs of labor and capital. During 1976-81, for example, West Siberian drilling nearly quadrupled—principally because both the number of brigades and the number of active drilling rigs more than quadrupled (table 6).

25X1

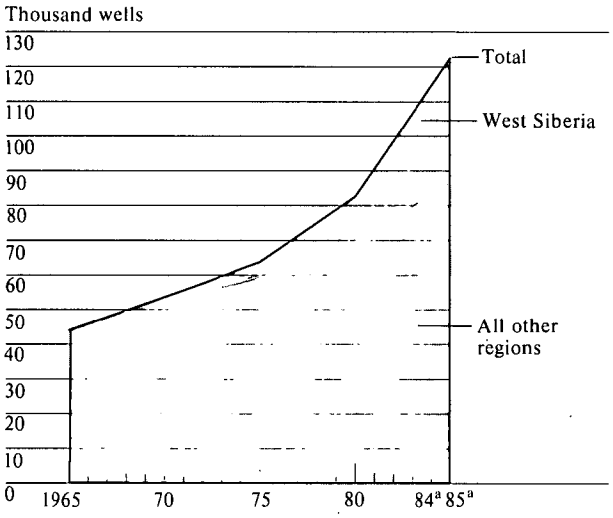
Labor

25X1

Drilling operations by the oil ministry involve more than 200,000 workers. In mid-1981, according to a Soviet oil-industry journal, there were 1,332 drilling

25X1

Figure 6
USSR: Oil Ministry Production Wells, by Region, 1965-85



[a] Planned.

302956 6-84

Table 6
USSR: Active Rigs and Drilling Brigades in West Siberia, 1971-81

	Active Rigs		Drilling Brigades	
	Number	Annual Percentage Increase	Number	Annual Percentage Increase
1971	31		29	
1972	37	19	30	3
1973	47	27	33	10
1974	55	17	39	18
1975	62	13	53	36
1976	81	31	73	38
1977	95	17	78	7
1978	124	31	112	44
1979	201	62	160	43
1980	252	25	188	18
1981	282	12	229	22

Note: These figures are computed from the annual averages for commercial speed (meters drilled per rig per month) and for drilling brigade productivity (meters drilled per brigade per year). These measurements are discussed in the section on drilling productivity and shown in table 10.

25X1

25X1

brigades, 380 rig-assembly brigades, and 195 well-testing brigades in the USSR [13]. We estimate, from data on meters drilled per brigade, that about 20 percent of the drilling brigades and associated groups were in West Siberia. Another 40 percent were exploration drillers, working principally in older regions.

A brigade usually has 20 to 30 drillers, but the entire drilling effort involves another 200 workers to support each drilling brigade.

A 1981 press report indicated that the number of workers per brigade was virtually unchanged two years later [14]. This figure suggests that the Soviets' addition of 151 drilling brigades in West Siberia over the period 1977-81 involved nearly 34,000 additional workers.

Although the number of drillers normally operating a Soviet drilling rig at one time—five workers—is comparable to typical US operations, support workers far exceed the normal number in the United States. Soviet drilling administrations reportedly spend considerable time repairing defective drill pipe and other equipment received from Soviet plants.

25X1

25X1

25X1

25X1

25X1

25X1

25X1

The number of workers per brigade apparently varies by region. West Siberian drilling organizations generally had 30 percent more

25X1

25X1

25X1

25X1

Our estimate of the Soviets' future drilling brigade requirements involves two basic uncertainties: (1) the number of new drilling brigades the oil ministry can add annually, and (2) the geographic distribution of these new brigades. Using the figures from our drilling productivity projections (see section below) and the 1985 oil ministry drilling plans, we find that the Soviets would have to add 90 to 235 brigades between 1983 and 1985. (Between 1981 and 1983 they added about 100.)[7]

25X1

Our estimate of the oil industry's labor requirements for 1986-90 is based on our projection that the Soviets could increase the number of brigades by 20 to 60 per year. Such additions—when combined with the regional differences in brigade size—yield the following ranges in the number of drilling-associated workers in 1985 and 1990:

1981	1985	1990
210,000	230,000 to 240,000	250,000 to 300,000

Thus, the drilling effort probably will require 20 to 50 percent more workers in 1990 than in 1981. Although the industry probably will still have labor turnover problems, it probably can achieve such an increase over a nine-year period. The upper end of this range—60 brigades per year (20 percent more than the 1981-83 pace)—probably is the fastest pace that the Soviets can sustain over a five-year period.

25X1

Several statements by Soviet officials and oil specialists have suggested there are limits to the number of new brigades that can be added to the drilling effort. For example:

- In late 1982 Gosplan Chairman N. K. Baybakov said that the drillers' task was "to ensure the accomplishment of growing amounts of drilling without increasing the number of brigades." [17]

25X1

workers than those in well-established areas. Exploration crews, which by their nature are more mobile than development drilling crews, are presumably smaller—perhaps only half the size of West Siberian production drilling organizations. Factoring in these differentials, and assuming that 229 of the 1,332 oil ministry drilling brigades were in West Siberia and that 535 were exploration brigades in both West Siberia and elsewhere, we estimate that the oil ministry's national drilling effort involved about 210,000 people in 1981.[5] The total number of drilling workers represents about a 20-percent increase over 1970.[6] The oil ministry's rapid gains in drilling (it more than doubled between 1970 and 1981) were due in large part to the shift in labor toward West Siberia, where drilling productivity was higher than elsewhere.

25X1

[5] A Soviet oil industry journal suggests the number may be slightly higher. It states that in 1980 there were 115 workers per drilling rig [15]. According to a Soviet technical journal, the oil ministry had at that time "over 2,000 rigs" [16]; if we assume this to mean between 2,000 and 2,100, the figure implies 230,000 to 240,000 workers.

[6] The number of oil ministry drilling brigades increased by 216 (19.3 percent) between 1971 and 1981, according to published Soviet data.

25X1

[7] The oil ministry added a *total* of less than 200 drilling brigades in 1970-80. The 1981-85 Plan (using Soviet drilling productivity targets) implied an increase of 166 brigades, or about 35 per year.

25X1

25X1

25X1

25X1

- A 1982 *Izvestiya* article referred to drillers as "specialists of the scarcest profession . . . (they) become highly qualified after five to six years of work, and even then not all of them reach this level." [18]

- In 1983 a deputy oil minister noted that drilling requirements would rise in the later 1980s and said: "It is unrealistic to count on forming hundreds of new [drilling] brigades; we need to solve problems by skills." [19]

Morever, rising requirements for drilling resources by the gas and geology ministries will further constrain the oil ministry's ability to increase the number of drillers.

The gas ministry plans to drill 10.4 million meters in 1981-85. Most of this drilling will be in difficult conditions—in the remote Urengoy and Yamburg fields in West Siberia; in high-sulfur, corrosive gas fields in the Caspian area and Central Asia; in very deep formations in the Caucasus and Ukraine; or offshore. At the Urengoy field (the source of all scheduled growth in Soviet gas production during 1981-85) the ministry has far fewer drillers than planned. This apparent shortage of labor at its most important field suggests that the gas ministry's priority in drilling allocations is lower than that of the oil ministry. We expect this lower priority to continue during the 1980s. Rapid increases in oil ministry drilling are clearly essential for high oil production levels, but drilling by the gas and geology ministries, while important, is less of a determinant of production.

Investment

Investment in the oil industry has risen rapidly in recent years, largely because of increases in the amount and costs of drilling. According to official statistics, 8.7 billion rubles were invested in the oil industry in 1982—31 percent more than in 1980 [20]. The current five-year plan calls for an investment 63 percent greater than that of 1976-80 [21]. This implies that the oil industry was slated to receive an investment of about 8.5 billion rubles annually during 1981-85, but, given the rapid and above-plan increases in 1981 and 1982, actual investment probably will be higher. Investment data reflect the priority accorded to the oil industry—this sector received nearly 60 percent of the 1981-82 increase in total industrial investment.

25X1

Within oil industry investment, the share of drilling outlays can be calculated roughly from reported meterage and our fragmentary data on cost per meter drilled. Table 8 presents these cost data and our estimates of drilling costs for 1980, 1985, and 1990. Each estimate is presented as a range, in which the lower figure is based on an extrapolation of the overall cost trend of the decade 1970-79 and the higher is projected on the trend of accelerating costs encountered in 1977-79. According to a Soviet oil handbook, ruble costs per meter are usually based on an estimated (*smetnaya*) cost. This is about 6 percent higher than the *sebestoimost'* (the Soviet concept of production cost), because the *smetnaya* cost includes anticipated profit. In any case, these ruble costs may understate growth in cost if judged by Western standards, because they exclude an adequate capital charge.

25X1

On the basis of these cost assumptions, we estimate that investment in drilling by the oil ministry was 2.9-3.0 billion rubles in 1980—or 45 percent of all oil industry investment, as reported in official statistics.[8] This calculation is consistent with recent statements in the Soviet technical literature that investment in drilling represents 40 to 50 percent of oil industry investment [22].

25X1

We also project that the oil ministry's drilling costs will be 5.1-5.4 billion rubles in 1985 and 8.6-10.3 billion in 1990. This calculation is based on the midpoint of the cost estimates in table 8 and the estimates of the ministry's exploratory and development drilling for 1985 and 1990, as shown in table 13.

25X1

[8] A statistical analysis of the relationship between drilling cost and investment is presented in appendix E.

25X1

25X1

25X1

Table 8 *Rubles per meter*
USSR: Drilling Costs, 1965-90 [a]

	Exploration Drilling	Development Drilling
1965	149 [b]	66 [b]
1966	160 [b]	
1967	163 [b]	61 [b]
1968	186 [b]	
1969	231 [b]	
1970	239 [b]	85 [b]
1971	253 [b]	86 [b]
1972	259 [b]	94 [b]
1973		
1974		
1975	314 [c d]	105 [d]
1976		
1977	356 [e]	106 [e]
1978	381 [c]	113 [f]
1979	403 [d]	119 [d]
1980 (estimate)	413-427 [g]	121-126 [g]
1985 (estimate)	505-544 [g]	139-160 [g]
1990 (estimate)	598-661 [g]	157-193 [g]

[a] The sources presenting these cost data give no indication of the price base used. Therefore, these estimates may include some inflation, but probably no more than is imbedded in Soviet investment numbers, which are expressed in 1973 rubles.
[b] Robert W. Campbell, *Trends in the Soviet Oil and Gas Industry* (Baltimore, Johns Hopkins University, 1976), pp. 16-17.
[c] N. I. Buyalov, S. Ya. Kaganovich, *Ekonomicheskaya effektivnost' geologorazvedochnykh rabot na neft' i gaz* (Moscow, Nedra, 1980), pp. 18-19.
[d] *Neftyanik*, No. 1, January 1981, p. 22.
[e] M. M. Brenner, *Ekonomika geologorazvedochnykh rabot na neft' i gaz v SSSR* (Moscow, Nedra, 1979), p. 167.
[f] The estimate of 1978 development costs is based on the assumption that the ratio between exploration and development costs is the same as in 1977.
[g] See text for the basis of our estimates.

These cost estimates suggest a rising investment requirement for the Soviet oil industry. The requirement may in fact be higher, because our estimates may not fully capture new elements of costs that perhaps could push upward the annual increases in investment. Such elements include the following:

- An increased drilling effort accelerates the industry's requirements for rigs, pipe, bits, and other equipment—which may not be available in sufficient quantity and quality because of deficiencies and shortfalls in industries producing drill rigs and equipment.
- If drilling investment is to be effective, it must be accompanied by investment in the relevant machine-building sectors as well as in such infrastructure as roads, electric power, and housing.

25X1

Combining our cost estimates with the assumption that drilling costs will continue to represent, on average, 45 percent of total oil industry investment (a percentage based on 1970-82 data), we can estimate oil industry investment in 1985 and 1990. If the oil ministry chooses drilling levels in line with the drilling scenarios we consider most likely, oil industry investment will rise from 8.7 billion rubles (1973 "constant" prices) in 1982 to about 12 billion rubles in 1985 and 19-23 billion rubles in 1990. Such a rapid increase in oil investment will be difficult to bear at a time of slow growth in total Soviet investment, combined with increasing demands from other energy sectors and from nonenergy programs, such as the food program.

25X1

Drilling Productivity

A common theme in Soviet technical discussions of drilling has been the need to increase drilling productivity rather than continuing to rely primarily on increased inputs of labor and capital. (Productivity in drilling is measured in meters drilled by a given unit in a given time.) Although Soviet drilling productivity is improving, it remains low by world standards. For example, US drilling rigs are two to three times more productive in terms of meters drilled per year than Soviet rigs. (See table 9 for Soviet drilling productivity and appendix C for a discussion of Soviet drilling technology.) Because the Soviets will find it harder to muster large increases in manpower and equipment in the 1980s than they did in the 1970s, their plans for drilling growth in the 1980s rest in large measure on plans for productivity gains.

25X1

25X1

25X1

25X1

Determinants of Drilling Productivity

The Soviets measure drilling productivity in several ways and frequently publish data for five separate indexes:

- Commercial speed—*meters drilled per active drilling rig in one 30-day month.*
- Mechanical speed—*meters drilled per hour of bit rotation.*
- *Meters per bit—the average number of meters drilled by a single bit before it wears out.*
- Meters per brigade—*meters drilled by a single drilling brigade in one year.*
- Meters per worker—*meters drilled per drilling worker in one year.*

Commercial speed, mechanical speed, and meters per bit are functions of the level and quality of technology and equipment, the depth of the reservoir, and the characteristics of the rock being drilled. Measures of the meters per brigade and per worker reflect organizational and logistic problems as well. These factors have a negative effect on productivity in the following ways:

- Equipment and technology. *Most Western analysts consider Soviet drilling technology to be far below Western standards [23]. Problems with drill pipe, blowout preventers, drilling fluid technology, and drill bits hamper Soviet drilling operations.*
- Depth. *Drilling productivity declines sharply with depth. At greater depths, the pressure and temperature are generally higher and the rock is harder, all of which reduce bit life and penetration rates. The degree to which productivity falls with depth depends largely on the quality of equipment and the rock conditions. As discussed in appendix C, the Soviets' primary drilling tool is the turbodrill, whose productivity tails off especially quickly with increasing depth. Rotary drilling is less quickly affected, but it too slows with depth. (The longer the drill string, the more time is spent in raising and lowering the drill pipe to change the bits worn out by the greater temperature and pressure.) According to Soviet statistics, the drop in commercial speed is especially sharp beyond 3,000 meters (figure 7).*
- *Type of rock. The soft sandstone and siltstone reservoir formations of West Siberia are far easier to penetrate than the harder limestone and dolomite formations of the Volga-Urals region. (Table 9 illustrates the wide regional differences in productivity.)*

25X1

25X1

In the 1970s

On the whole, the productivity of oil ministry drilling rose during 1970-81. Behind this trend, however, and accounting for most of the rise, was the increasing importance of West Siberia in the overall picture. As a contributing factor, the share of development drilling was increasing and that of exploration drilling was declining. Table 10 shows that, in terms of meters per brigade, the ministry's development drilling productivity in West Siberia is three times the average for the entire country.

West Siberian drillers met plans through the mid-1970s, but they could not keep up with the rapid acceleration of targets in 1977-80. They missed the 1980 target by about 1.2 million meters (12.5 percent).

In the late 1970s, a central problem of West Siberian drilling was the decline in brigade productivity, as shown in table 10. This decline is attributable to several factors:

- The role of Samotlor, the largest Soviet oilfield, was diminishing, and it was the Samotlor brigades that set most of the West Siberian drilling records. Overall brigade productivity is as much as 60 percent better in this supergiant field than in other West Siberian fields, principally because of easier drilling conditions and well-established infrastructure [24]. Samotlor's share of total drilling in Tyumen' declined from 55.6 percent in 1975 to 14.5 percent in 1981, and its contribution to Tyumen' production fell from 58 to 46 percent,

25X1

25X1

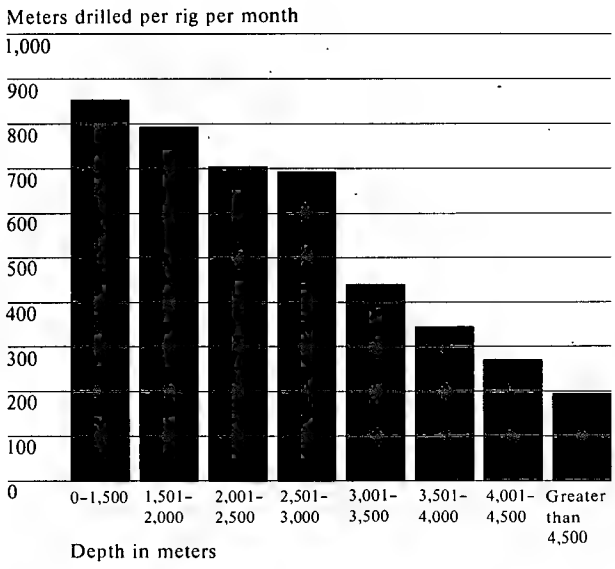
25X1

25X1

25X1

25X1

Figure 7
USSR: Drilling Efficiency and Well Depth (exploration drilling)



302957 6-84

Table 9
USSR: Drilling Productivity by Region in 1977

Meters drilled per worker

Oil Region	Productivity	
	Of All Drilling	Of Exploration Drilling Only
USSR (overall average)	**110.3**	**40**
West Siberia	276.7	212
Bashkir ASSR	177	100
Tatar ASSR	210	384 [a]
Perm'	154	107
Mangyshlak	144	
Udmurt	233	
Tomsk	329	
Kuybyshev	99	80
Ukrainian SSR	30	24
Checheno-Ingushkaya ASSR	31	
Komi ASSR	86	30
Azerbaijan SSR	87	28
Georgian SSR	90	
Turkmen SSR		34

[a] The high productivity of exploration drilling in the Tatar Republic (a part of the Volga-Urals region) seems anomalous. It may be due to the fact that recent Tatar exploration has emphasized shallower deposits that are easier to drill.

Source: M. M. Brenner, *Ekonomika geologorazvedochnykh rabot na neft' i gaz v SSSR* (Moscow, Nedra, 1977), pp. 165-166.

25X1

25X1

decline of this field's share of drilling in West Siberia appears to have been a principal cause of the decline in West Siberian brigade productivity in 1976-79.

- The Soviets moved to small, isolated fields hundreds of kilometers from established infrastructure. In such fields, the logistic failures and supply shortages are particularly severe, and the share of idle time is increased.

- Reservoirs in many of the newer fields (such as Kholmogorsk, Pokachev, Var'yegan, and Lyantor) are 200 to 500 meters deeper than the principal reservoirs at Samotlor [25]. Depth increases of this kind present no technological problem, but they increase the drilling time per well.

- The rapid increase in the number of West Siberian drilling brigades—from 83 in 1978 to some 230 in 1981—slowed their individual productivity, as supplies and experienced personnel were stretched thin. Press reports indicate that untrained personnel are hampering the brigades' work, shortages of drill pipe and casing are chronic, and equipment is being operated beyond its normal service life and becoming less efficient [26].

- Expeditionary crews from other areas, who on average are less productive than crews accustomed to working in West Siberia, began to take an increasing share of the area's total drilling load.

The late 1970s decline in West Siberian drilling productivity began to turn around in 1980.

25X1

25X1

25X1

Table 10
USSR: Productivity Trends in Oil Ministry Development Drilling, 1970-81

	Meters per Brigade [a]	Commercial Speed [b]	Mechanical Speed [c]	Meters per Bit
Nationwide				
1970	7,545	1,120	9.7	34.5
1971	8,285	1,137	9.8	36.6
1972	NA	NA	10.2	39.6
1973	NA	NA	11.0	44.8
1974	NA	1,447	11.7	49.5
1975	9,603	1,576	11.6	54.4
1976	9,205	1,494	11.5	60.3
1977	NA	NA	NA	NA
1978	11,405	1,713	12.8	76.1
1979	12,291	1,677	NA	84.3
1980	13,951	1,697	NA	NA
1981	15,743	1,791	NA	NA
West Siberia Only				
1970	34,369	2,956	32.7	111.5
1971	40,200	3,091	36.2	118.0
1972	46,200	3,115	38.9	158.0
1973	56,400	3,281	37.6	193.9
1974	58,600	3,493	36.2	198.2
1975	53,053	3,739	35.6	NA
1976	46,890	NA	35.2	NA
1977	48,547	3,339	35.5	206.3
1978	43,692	3,293	34.0	199.2
1979	42,435	2,815	34.2	199.5
1980	44,798	2,779	33.6	195.0
1981	48,037	3,246	32.5	188.9

[a] Meters per brigade = meters drilled by a single drilling brigade in one year.
[b] Commercial speed = meters drilled per active drilling rig in one 30-day month.
[c] Mechanical speed = meters drilled per hour of bit rotation.

NOTE: Information compiled from unclassified Soviet texts and journals.

In the 1980s

The oil ministry's plans call for meterage per brigade to rise by more than 50 percent between 1980 and 1985 (from about 14,000 to over 21,000 meters per brigade nationwide) [27]. We calculate that if the 21,000-meter goal is met by 1985, only about half of the 7,000-meter increase will have been accounted for by an increase in drilling productivity. The rest will come from two changes in drilling activity: the regional shift to West Siberia and the ministry's shift of emphasis from exploration drilling to the more efficient development drilling.

25X1

Drilling increases in the 1980s will come principally from the oil ministry, although drilling by the gas and geology ministries also will rise. How much the Soviets will be able to do depends both on the outlook for drilling productivity and on how fast they can increase the number of brigades.

25X1

As noted above, drilling productivity varies widely according to geologic conditions. In one year, for example, 100 experienced brigades could do roughly 5 million meters of development drilling in West Siberia but only 1.0-1.5 million in most other regions. In the same period, the same brigades could do only 500,000 meters of exploration drilling (with some regional variation). This is because drillers must proceed cautiously in unknown formations, monitoring lithology and pressure as they go; because exploration drilling targets are often formations deeper than those currently in production; and because of communication and supply difficulties related to the remoteness of some operations from administrative and supply centers.

25X1

Although plans call for large increases in exploration drilling during the 1980s, we estimate that the Soviets will divert resources from exploration to development drilling if they think the diversion will help hold production stable. In addition, given the importance of drilling to oil production, we estimate that the oil ministry will be given priority over the gas ministry in onshore development drilling.

25X1

West Siberian Development Drilling. West Siberia will remain the main focus of drilling increases in the 1980s. We estimate that productivity in this region could increase substantially, perhaps by 25 to 45 percent between 1981 and 1990.[9] This estimate is

25X1

[9] In 1981, West Siberian drilling productivity was already 13.2 percent above the 1979 rate. Presumably some of the factors enumerated above began to leave an impact before 1981. Nevertheless, we chose 1981 as a base year to allow for sources of productivity gains not included in the calculations summarized in table 11

25X1

25X1

based on our evaluation of several factors, favorable and unfavorable, relevant to the West Siberian effort.

Favorable factors include the following:

- Substantial gains probably will be made during the 1980s as the Soviets step up their effort to improve the infrastructure in West Siberia. Workers from Leningrad, Kiev, and other cities have been recruited to work, notably on roads and housing. Despite some continuing shortcomings, West Siberian infrastructure is being improved The improvements may enable the Soviets to reduce the percentage of inactive rigs in West Siberia (see appendix B). If a shortage of drill pipe is a key factor in this idleness, as appears likely, imports could ease the problem.

the size of drilling pads in the West Siberian swamps is increasing. These pads are artificial islands from which directional wells are drilled downward and outward, generally in clusters of eight. Older pads have eight to 16 wells, but pads with 16 to 48 are becoming more common, and one oilfield has pads with 60 to 80 wells. Larger pads sharply decrease the time lost in moving rigs, possibly eliminating one or two interpad moves annually. Interpad moves can take as long as a month, while moves within a pad can be made in four days.

- After more than 20 years of drilling in West Siberia, the Soviets are higher up on the learning curve and better able to solve drilling problems.

Despite the potential for continued productivity gains, a number of unfavorable factors will dampen the extent of the productivity gain in West Siberia:

- Despite infrastructure improvements, labor turnover in this harsh climate continues to be a problem. In 1983, according to a press report, the Nizhnevartovsk production organization hired 300 new workers, but 200 of its other workers left [28]. Such a turnover slows expansion and lowers the average experience level of the work force.

- Although they drill faster in West Siberia than in other regions, experienced brigades from other areas apparently require two to three years to come up to speed in West Siberia [29]. New drillers, on the other hand, may require five to six years of experience before they become proficient [30]. Because new workers continue to constitute a large part of the total work force, productivity will be hampered.

- Geological conditions, such as depth and rock hardness, are somewhat worse in West Siberia's new fields than in the older ones, according to Soviet technical journals [31]. Although this trend began in the late 1970s, these newer fields will play a much larger role in the 1980s than they did in the 1970s.

- Factors beyond drillers' control—such as electric power outages and severe weather—probably will continue to be a problem. Nearly all West Siberian drilling is powered by electric motors.

Improvement in this area hinges on very ambitious plans for power plant construction in West Siberia during the 1980s.

- Overall productivity gains in the oil ministry in the 1970s were due in part to the shift of many brigades from the less productive exploration drilling to the more productive development drilling. In 1975-79, for example, the number of exploration drilling brigades declined by more than 21 percent in consequence of the increased emphasis being placed on meeting high production goals [32]. The shift of brigades from exploration to development provided a potential increase of 2-5 million meters in development drilling, depending on their geographical allocation. Further productivity gains from this source are unlikely if the Soviets are serious about their plans to increase exploration in the 1980s.

Table 11 combines our estimate of the quantitative impact of these favorable and unfavorable factors.

25X1

Table 11
Details of West Siberian Drilling Productivity: Estimated Net Effect of Favorable and Unfavorable Factors, 1981-90

	Estimated Change in Productivity
Favorable factors	
Decreased drilling rig downtime due to improved supplies and infrastructure [a]	23 to 30 percent
Larger drilling pads [b]	7 to 15 percent
Improved drill bits and other equipment [c]	10 percent
Higher on the learning curve [d]	5 percent
Unfavorable factors	
Labor turnover [d]	−5 percent
Worsening of geologic conditions [e]	−5 percent
Power outages, weather problems [f]	−5 to −10 percent
Net effect	**25 to 45 percent**

[a] Assumes 90 to 95 percent of the assembled rig park is operating in 1990, rather than the 73 percent during 1980-81.
[b] Assumes brigades save one or two interpad moves annually.
[c] Soviet 1985 plans called for a doubling of meters drilled per bit between 1980 and 1985. Given published complaints about bits and problems in the new bit plant acquired from the United States, we estimate that such a doubling may not occur until 1990. Bit changing operations occupy about 10 percent of total drilling time, according to a Soviet journal. Cutting these operations in half by doubling bit life would improve productivity by 5 percent. Other equipment improvements will also help, but probably by no more than the 5 percent attributed to bit improvement.
[d] Difficult to quantify, but probably of same order of magnitude as bit improvement.
[e] In the late 1970s in West Siberia, bit productivity remained constant, despite bit improvements, because of worsening geologic conditions, according to a Soviet oil journal. These conditions are expected to continue to worsen, probably again roughly equal to the improvement in bits.
[f] Difficult to quantify, but probably of same order of magnitude as bit improvement; possibly worse if infrastructure fails to keep pace with the move to many distant and isolated fields.

Combining them, we estimate that West Siberian drilling brigade productivity will be 55,000 to 56,000 meters per brigade in 1985 and 60,000 to 70,000 in 1990 (table 12).

Development Drilling in Other Regions. The productivity of development drilling in regions other than West Siberia depends on the average depth of new drilling targets and the priority accorded these areas.

Table 12
USSR: Projected Drilling Productivity in the Oil Ministry in 1985 and 1990

Meters per brigade per year

	1981	1985	1990
Development drilling			
West Siberia	48,000	55,000 to 56,000	60,000 to 70,000
Other regions	13,400	13,200 to 14,100	13,000 to 15,000
Exploration drilling	4,300	4,300 to 4,500	4,300 to 4,800

Note: see text for discussion of projection techniques. Calculations are based on the average 1982-90 productivity growth rate.

25X1

A focus on deeper drilling, combined with an effort funneling most new equipment to West Siberia, could push productivity levels slightly below the 1981 level. A focus on shallower drilling in the Volga-Urals region and Kazakhstan's Buzachi Peninsula, combined with some improvement in equipment, could raise the other regions' productivity by about 10 percent. This is comparable to the estimated impact of improved equipment in West Siberia shown in table 11.

25X1

Table 12 shows the range of possibilities under these two focuses. A 10-percent improvement would bring estimated 1990 drilling brigade productivity to about 15,000 meters per brigade.

25X1
25X1

Exploration Drilling. Exploration drilling productivity in the 1980s also will depend heavily on drilling conditions encountered and on the priority assigned to the effort. It probably will be no worse in 1990 than in 1981, as much of the oil ministry's increased effort probably will be in West Siberia, where exploration drilling productivity is relatively high. Using basically the same analysis as was used for non–West Siberian development drilling, we estimate at best a 10-percent improvement over 1981 productivity levels (table 12).

25X1

25X1

25X1

25X1

Drilling by the Oil Ministry

In 1981-85

Oil ministry plans for 1985 call for less than 19 million meters of development drilling in West Siberia and some 8.5-9 million meters in other regions, and for about 3 million meters of exploration drilling (table 4). Nearly all of the increase will be in West Siberia. These plans, taken together with the drilling productivity (meters per brigade) trends projected above, imply that in 1985 the USSR as a whole will need 1,560 to 1,700 brigades—110 to 250 more than the number on hand in early 1983.

25X1

We believe the oil ministry will be hard pressed to add brigades faster in 1984-85 than it did in 1982-83, when it added about 50 per year. Many of its gains in recent years were made at the expense of the gas and geology ministries. Although we expect oil ministry development drilling to continue to have first claim on drilling resources, the increasing requirements of the other ministries cannot be ignored indefinitely.

25X1

The oil ministry's regional allocation of drilling resources will have a large impact on drilling levels. Experienced drillers are generally more productive in West Siberia than in their home regions, and, as indicated above, the transfer of drillers to West Siberia has brought substantial gains in the past six years.

Nonetheless, we estimate that three factors are combining to diminish the benefits of additional transfers to West Siberia: the difference between new well flows in West Siberia and other regions is diminishing, West Siberian production operations are growing more complex, and managerial difficulties and infrastructural requirements are increasing (see figure 8 and inset).

Equipment requirements will increase correspondingly, but the oil ministry probably will be able to meet them. Problems of low quality and delivery bottlenecks probably will remain. Specifically:

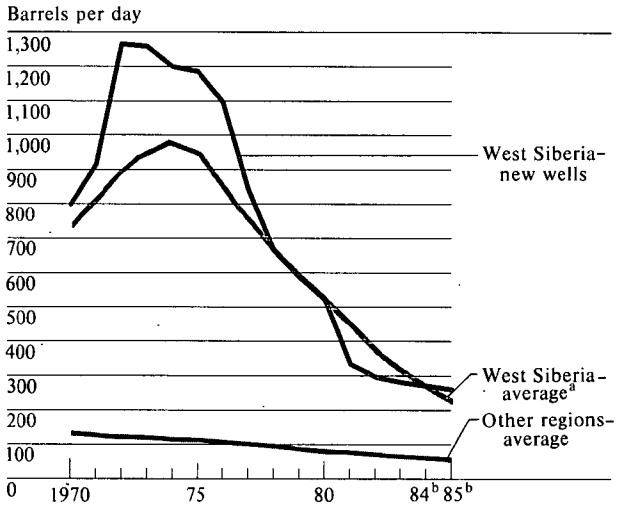
- The estimated 1,560 to 1,700 drilling brigades will require 2,500 to 2,700 rigs in 1985 (an estimate based on the 1980 rig-to-brigade ratio of about 1:1.6). Planned increases in rig production probably will cover these needs, and the ministry may also continue to use rigs beyond their normal lifetime.

25X1
25X1

- Drill bit requirements of some 200,000 to 300,000 bits in 1985 probably will be met, with a new drill bit plant in Kuybyshev added to existing production capacity.

25X1

Figure 8
USSR: Oil Well Flows, 1970-85



[a] The apparent anomaly—that average West Siberian well flows fell in the 1975-77 period while new well flows were above average—is due to the fact that declining flows from the more numerous old wells were swamping the impact of higher flows from new wells.

[b] Planned.

302958 6-84

25X1

25X1

25X1

25X1

Diminishing Returns From Drilling Resources Transferred to West Siberia

Diminishing Difference in New Well Flows

Although new West Siberian well flows probably will continue to be above the average for other regions, this differential is narrowing (see figure 8). Production efforts in West Siberia always have been costlier, but the difference was quickly made up when new well flows were about 1,000 b/d higher than elsewhere (as was the case in 1975). Now, however, the Soviets are working on less productive formations in West Siberia; by 1980 the differential in new well flows had declined to about 300 b/d, and by 1985 (according to preliminary information published on the 1981-85 period) it will be less than 100 b/d. At some point, the differential will no longer offset the higher costs of West Siberian production plus the opportunity cost in the old regions in terms of idle pipelines and production and processing capacity.

We estimate that the Soviets originally planned for 1981-85 to obtain over one-third of their new production capacity from regions outside West Siberia. Moreover, the effort required to create new capacity increases as an oil region matures, leading to more difficult choices in allocating resources between regions. Too great a transfer of resources out of older regions could curtail their production sooner and more severely than planned.

Growing Complexity of West Siberian Production Operations

In 1983 the drillers in West Siberia outpaced the workers who connect and manage the wells. It is pointless to increase drilling faster than the new wells can be assimilated. According to press reports many of the producing wells in Tyumen' were idle for various reasons in 1983 [33]

25X1

25X1

Three interrelated factors—rising water cuts,[a] rising requirements for water injection, and the rising share of wells using artificial-lift equipment—are complicating the West Siberian effort, raising equipment and manpower requirements, and apparently turning oil ministry decisionmakers' focus away from drilling and toward solving the problems that come after a well is drilled. The ministry has recently taken steps to rapidly expand the West Siberian production work force—those who connect, operate, and repair the wells. Nevertheless, the pressures caused by this growing complexity will continue throughout the 1980s and beyond.

25X1

25X1

Managerial Difficulties and Infrastructural Constraints

Some of the West Siberian problems cited earlier—the use of untrained labor, the use of equipment beyond normal limits, supply problems, and labor turnover—probably will worsen as the pace of drilling accelerates. If these problems become severe, they may slow the growth in the number of drilling brigades. Furthermore, the infrastructure costs of developing some of the more remote and less productive West Siberian oil deposits may push development costs far beyond the cost of intensifying oilfield development in the older areas, or in such other new regions as the Komi ASSR.

25X1

25X1

[a] The water cut is the percentage of water in the total fluid (oil and water) produced from oil wells.

25X1

- Estimated requirements of drill pipe and casing of 6-7 million tons probably will continue to be a problem, but imports could ease the situation (potential suppliers are numerous). We estimate that the Soviets will continue to seek substantial quantities of oil tubular goods in the world market.

25X1

25X1

Table 13
USSR: Drilling by the Oil Ministry in 1982, 1985, and 1990

Million meters

	1982		1985		1990	
	Plan	Actual	Plan	Forecast	Plan	Forecast
Total	**24.4**	**23.3**	**30.5**	**28.4 to 29.9**	NA	**35 to 50**
Development	22.0	20.8	27.5	25.7 to 27.0	NA	32 to 46
West Siberia	NA	12.5	18.6	17.7 to 18.5	NA	26 to 37
Other regions	NA	8.3	8.9	8.0 to 8.5	NA	7 to 9
Exploration	2.4	2.5	3.0	2.7 to 2.9	NA	3 to 4

25X1

Drilling technology and equipment are discussed further in appendix C.

Taking these equipment factors into account, we estimate the oil ministry will be able to drill 28-30 million meters in 1985 (see table 13). Given the importance of West Siberia and the relatively modest drilling targets for 1984 and 1985, we estimate that the Soviets will come close to meeting their target of 18.6 million meters, or at worst fall no more than 5 percent short of plan. Most of the drilling shortfalls will be outside West Siberia and in exploration.

In 1986-90

Given the emphatic statements of Soviet writers that drilling increases must come almost entirely from increased productivity and taking into account the previously discussed constraints, we believe that in 1986-90 the oil ministry will add no more than 60 drilling brigades annually. We estimate that most of these probably will go to the West Siberian effort. This is our maximum estimate. As a minimum, we estimate that (given the rising requirements for drilling) the Soviets will continue to opt for some increase, perhaps adding 20 drilling brigades per year. Combining these estimates for additional brigades with the productivity estimates discussed above, we project that the oil ministry probably will be able to drill some 35-50 million meters in 1990, of which 32-46 million meters will be development drilling (table 13).

The Soviets would be extremely hard pressed to exceed 50 million meters—which we consider to be an upper bound reflecting the assumptions of optimistic productivity gains and the addition of 60 brigades annually. Some of the problems hampering the drilling effort today, such as extended supply lines and shortages of equipment and skilled labor, probably will continue. Moreover, attempting to expand the drilling force by 60 brigades annually will increase the likelihood of bottlenecks and thus hamper productivity gains. A drilling-rig plant has recently been built that probably can supply enough rigs through 1985, but more plants will be needed for the later 1980s if the Soviets are serious about substantially increasing their exploration drilling [34]. Acquiring additional foreign technology, such as turnkey drilling-equipment plants, can help, but the negotiations for construction of such plants require so much leadtime that the impact would be relatively small in the 1980s. Importing equipment, notably drill pipe and casing, can also help, but cannot solve the Soviets' equipment problem.

25X1

25X1

25X1

25X1

Impact on Oil Production

In 1985, even if oil ministry drilling falls at the low end of our forecast (28.4 million meters), the impact of the shortfall on oil production could be minimal if the drilling is optimally located, if development drilling continues to have priority, and if Soviet drilling plans

25X1

25X1

25X1

accurately reflect requirements. Any shortfalls that occur would probably be concentrated in exploration drilling and in the least productive areas.

On the other hand, the Soviet drilling planners may have underestimated drilling requirements. In an article in the December 1982 oil industry journal, oil minister N. A. Mal'tsev expressed the problem clearly: "Taking into account the depletion of existing capacity, a 1-million-ton (20,000 b/d) increase in oil and gas condensate output required 265,000 meters of drilling in 1970 and about 866,000 meters in 1980; by 1985 it will be necessary to drill 7 million meters"[10] [35].

Mal'tsev may have understated the problem. In 1983, 6.2 million meters were drilled per 20,000 b/d of growth, rather than the 3.8 million meters anticipated in the plan. Only 27.5 million meters of development drilling are planned for 1985, but the differential between the 1984 and 1985 production plans suggests that 42 million meters actually will be required, or 50 percent more than planned. If Mal'tsev's calculation is correct, then Soviet drillers may be hard pressed to bring in enough new wells to prevent declines in oil production in 1984 and 1985.

The situation is likely to worsen in 1986-90. Two Soviet press articles written since late 1982 have implied that oilfield development drilling, slated to total 118 million meters during 1981-85, would need to double in 1986-90 to maintain current oil output [36]. Our analysis supports this statement.

Such a doubling would imply oil ministry development drilling of over 60 million meters by 1990—about 15 million meters more than the high end of our most likely range. We do not believe that the Soviets can achieve that much drilling, primarily because of the heavy strain it would place on investment. Considering the likely growth in resources allocated to drilling, we estimate that in 1990 they will be able to do at most about 45 million meters of development drilling—and probably will do at least 35 million meters. The actual amount will depend on new well flow rates, especially in West Siberia. Our analysis of West Siberian geological conditions indicates that new well flow rates will decline from about 580 b/d in 1980 to 230 to 260 b/d in 1985 and to 145 to 220 b/d in 1990.[11] If well flow rates in 1990 fall toward the low end of the estimated range (as we believe likely), a given amount of drilling will add only about two-thirds as much new capacity as it would if well flows were at the high end of the range. Our estimated range for new well flow rates, together with our projections of development drilling in 1990, are consistent with an oil production level of 10-12 million b/d.

Although the above analysis points to drilling as a constraint on oil production in the 1980s, a production forecast cannot be made on the basis of drilling alone. Discoveries in 1984 or 1985 of several large, high-flow deposits, although highly unlikely, could reduce drilling requirements in the late 1980s somewhat. Other production efforts, such as improvements in pumps, gas-lift units, well-workover procedures, enhanced recovery projects, and gas condensate recovery, are not principally dependent upon drilling efforts. Any improvement in these areas will reduce the burden on drilling in maintaining production.

[10] The 1970 and 1980 figures indicate that Mal'tsev was referring to development drilling.

[11] The estimated decline in new well flows reflects our judgment that the Soviets will be drilling in less productive structures and drilling infill wells in fields already producing. As drilling (and oil extraction) increases in a given reservoir, the natural pressure (and thus the rate of extraction) falls. As the pressure falls, wells must be converted to pump, and secondary and tertiary methods of extracting oil must be employed (that is, water injection, gas-lift operations, and so forth). This requires additional drilling of injector wells and increases the total volume of fluid that must be lifted for a given volume of oil.

Appendix A

Drilling Procedures and Organization

Drilling Procedures

In the USSR, development drilling after an oilfield is discovered proceeds in three general phases. First, several confirmation wells are drilled to learn more about the dimensions and geologic parameters of the field and to obtain early production data.

Second, based on the results from early production as well as on information from exploration wells, a field development plan is designed. As water injection often begins soon after the start of production, development plans also include water injection patterns. This plan establishes the initial well spacing for the entire field. Figure 9, the 1973 plan for the Samotlor field, is an example of a field development plan. The well spacing depends largely on the geological characteristics of the field and the expected flow rates. Generally, fields with lower flow rates require denser well spacing for full development.

Third, as the initial development plan is completed and more is learned about the field's characteristics, infill drilling (which creates a denser network of wells) is begun. This is generally done for one of two reasons—either to produce oil that cannot be produced from existing wells (because of unforeseen geological complexities or because the oil was bypassed by injected water) or to produce oil at a faster rate in the near term. The supergiant Romashkino oilfield in the Tatar ASSR, for example, has been redrilled three times [37]. Soviet oil specialists have questioned the wisdom of extensive infill drilling to boost near-term output. Academician A. P. Krylov argued in 1980 that an excessive emphasis on infill drilling at the expense of exploration drilling could lead to a rapid decline in Soviet oil output [38].

When Soviet writers refer to the "well construction cycle," they include the entire drilling operation—the transport and assembly of the rig, the drilling of the well, and its completion and testing. Considerable time is lost between the various stages, as each part of the cycle is done by a different brigade. Since the 1970s there has been a movement toward "consolidated" drilling brigades, which handle the entire cycle. The Soviets substantially shortened the average length of the cycle in the late 1970s—from 129 days in 1975 to 90 to 95 days in 1980—and they plan to reduce it to 75 to 80 days by 1985 [39]. In 1978 the cycle required almost 100 days, as follows [40]:

	Days	Percent of Total
Total well construction cycle	97.3	100
Rig assembly	10.4	11
Drilling	60.7	62
Well completion	26.2	27

25X1

In West Siberia, the same activities take less time—a total of only 44 days was average for Glavtyumennefteggaz in 1981 [41]. Interpretation of this difference is complicated by the widespread use of cluster drilling—the drilling of several wells from a single location. Each well is drilled quickly, in perhaps two or three weeks, but all eight to 16 wells in a cluster generally are not completed and readied for production until the last one has been drilled [42]. For an individual well, the delay between the end of drilling and its final completion can be substantial. In Nizhnevartovsk in 1975 the various delays amounted to more than half the total cycle time (table 14)—and the Nizhnevartovsk drilling administration has some of the best drilling averages in West Siberia.

25X1

25X1

25X1

Normal Drilling Administration and Organization

National onshore drilling efforts by the oil ministry are coordinated and administered by the ministry's administration for drilling operations. In addition, drillers are supported by research institutes in Moscow, Tyumen', and other cities. (The gas ministry controls offshore drilling.)

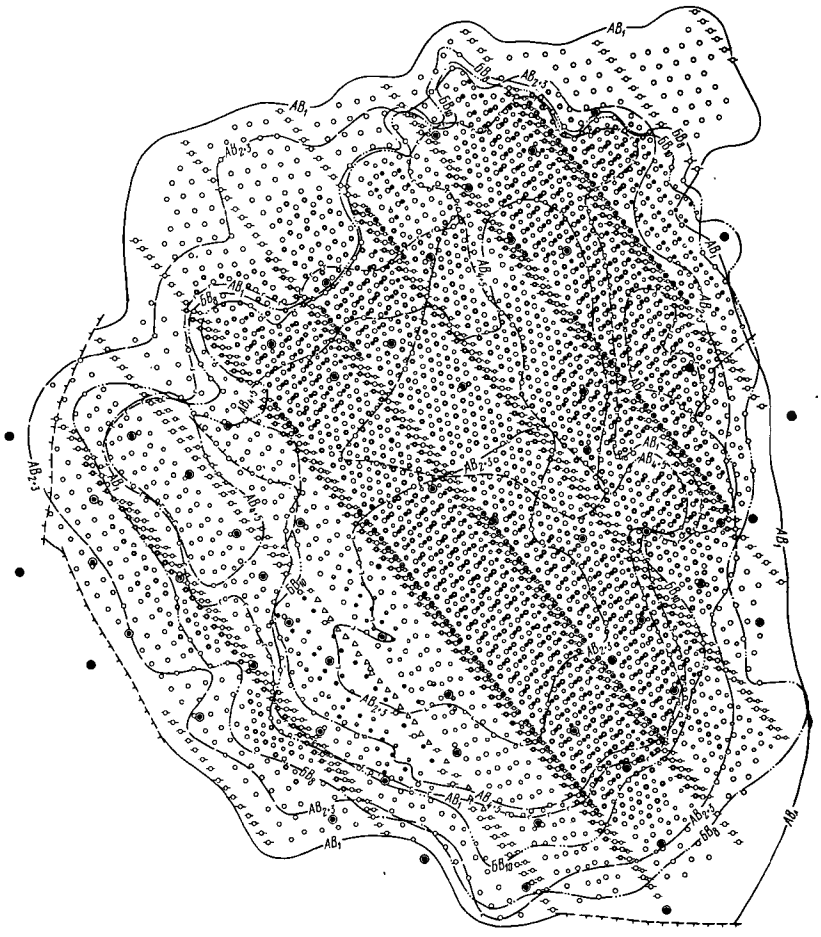
25X1

25X1

25X1

Figure 9
Development Plan for Samotlor Field (after Muravlenko, 1973)

- Exploratory wells.
- Development wells, drilled to objective A.
- Development and injection wells, drilled to objective B.
- Planned development and injection wells to BV_{10}.
- Planned development and injection wells to BV_8.
- Planned development and injection wells to AV_{2-3}.
- Planned development and injection wells to AV_1 and AV_{4-5} in five-row blocks and to objective A in three-row blocks.
- AV_1 oil reservoir.
- AV_1 gas cap.
- AV_{2-3} oil reservoir.
- AV_2 gas cap.
- AV_{4-5} oil reservoir.
- BV_8 oil reservoir.
- BV_{10} oil reservoir.
- Zone of facies change of BV_{10}.



Note: This development plan encompasses an area of approximately 1,000 square kilometers.

25X1

302959 6-84

25X1

25X1

Table 14
West Siberia: Time Required in the Well Construction Cycle, 1975

Steps in Well Construction	Days [a]	Percent of Total Time
Total cycle	**225.0**	**100**
Rig assembly	54.6	24
Drilling	24.5	11
Well completion	102.8	46
Well hookup	43.1	19

[a] The times include delays between individual steps. These delays together make up over half of the total time requirements.

The basic production units in the oil industry are the oil and gas production associations. Each of these has six deputy general directors. The deputy general director for drilling supervises the three drilling organizations—the drilling administration, the rig-assembly office, and the cementing (well-completion) office [43].

25X1

The drilling administration is the major center of drilling activity. A drilling brigade usually comprises 24 men, generally working in four teams on a single rig in shifts of up to 12 hours [44].

25X1

There are variations in the general pattern.

25X1

there were 21 men per brigade. Furthermore, at least some of the West Siberian drilling records were set by seven-team brigades operating two rigs [45].

25X1

25X1

Expeditionary Brigades

An alternative to the traditional drilling organization is the expeditionary drilling brigade, whose members retain their home residences but work in other regions. These units, also known as contract, shock, or watch brigades, are being widely used in West Siberia. The Soviets also use the method on a small scale in other regions. Volgograd drillers are working in Komi, and Groznyy and Krasnodar drillers are developing Georgian oilfields. Similar brigades also are used in construction and, to a lesser extent, in oil-production operations. US and Canadian companies have used similar methods on a smaller scale for development in Alaska and northern Canada (see appendix B).

25X1
25X1

25X1

Appendix B

25X1

Drilling in West Siberia

West Siberian production is the key to Soviet oil output in the 1980s. Oilfield development drilling in the region is handled by Glavtyumenneftegaz (Tyumen' Chief Administration for Oil and Gas) and by Tomskneftegaz (Tomsk Administration for Oil and Gas). The geology ministry's Tyumen' agency, Glavtyumengeologiya (Tyumen' Chief Administration for Geology), directs exploration drilling. The Soviet press indicate that in this region the oil ministry focuses almost exclusively on development drilling. In the 1982 drilling plan of Glavtyumenneftegaz, for example, only 150,000 meters (1.2 percent) were for exploration drilling.

25X1

25X1

Reversing the emphasis of the mid-1960s, the total drilling effort in West Siberia has come to emphasize development drilling at the expense of exploration. This change is illustrated by the shift in shares shown below (shares of total drilling, in percent) [46]:

	Exploration	Development
1965	72	28
1970	26	74
1975	18	82
1980 (estimate)	10	90

Soviet plans call for a slight further increase in the share of development drilling in 1981-85.

The neglect of exploration is particularly striking in the Middle Ob' region, the core of Western Siberian oil production. The principal source of "new" oil is prospecting wells. We identify these as active rigs that are more than 1.5 km from other drilling activity, and such rigs made up only 5 percent of drilling activity in this core region. The limited amount of exploration drilling would be reasonable if the USSR had an abundance of previously discovered reserves, but repeated published complaints that exploration is insufficient, suggest that this is not the case [47]. Indeed, a prominent theme of the new 20-year energy program currently being discussed is the need for greater emphasis on exploration drilling [48].

25X1

About 95 percent of oil ministry drilling in West Siberia is done in Tyumen' Oblast, the source of 97 percent of West Siberian oil output. The remaining 5 percent of drilling is in Tomsk Oblast, where some 700,000 to 800,000 meters are drilled annually and 200,000 to 250,000 b/d of oil are produced [49]. Within Tyumen' Oblast, drilling is controlled by five regional administrations.

25X1

25X1

25X1

Nizhnevartovsk, the source of some two-thirds of West Siberian oil output in 1980, is receiving a declining share of drilling, as West Siberian growth is coming principally from fields further to the west,

25X1

25X1

25X1

25X1

operated by the Surgut, Noyabr'sk, and Yugansk associations. We expect the basic trends shown for 1980-82 to continue. (The 1983 plan suggests a small increase from 1981-82 plans in the Nizhnevartovsk area, however. According to earlier plans, Nizhnevartovskneftegaz was scheduled to drill about 30 million meters in 1981-85, or about 40 percent of West Siberian drilling [50].)

The new Noyabr'sk association has a 1985 production target of 500,000 b/d, up from about 40,000 b/d in 1980 [51]. drilling activity in the Noyabr'sk fields is intense and that new fields in the Surgut area, such as Lyantor, are the sites of some of the greatest increase in drilling activity.

Drilling in the Nizhnevartovsk region will continue at a relatively high level. Within the region, according to press discussions, growth will come from fields to the north, in the Var'yegan area, rather than from Samotlor and its satellite fields.

Expeditionary Drilling Brigades

Thus far, drilling increases have been due to increases in inputs—brigades and rigs. The principal source of the increased effort has been expeditionary drillers from other regions. Brigades from outside West Siberia are scheduled to drill 28 million meters out of the 76-80 million meters planned for the region in 1981-85 [52]. The method appears to be eminently rational. Because of the geological conditions in West Siberia, visiting crews drill more meters in more productive wells there than they would have drilled in their home regions. In 1980, for example, expeditionary brigades in West Siberia averaged nearly 40,000 meters per brigade, whereas the drilling brigades in the Tartar ASSR averaged only 22,775 meters [53].

The Tatar example illustrates the impact of the expeditionary system. In 1980 Tatar brigades drilled 630,000 meters in Tyumen' [54]. We calculate—using reported average West Siberian well depths of about 2,400 meters and new well flow rates of 519 b/d—that the Tatar drillers added about 135,000 b/d of production capacity. Working in the Tatar ASSR, where well depths average 1,500 meters and new well flows average 50 to 70 b/d [55], the same crews would have drilled only 12,000 to 17,000 b/d of new production capacity. The shift of less than 20 brigades appears to have provided a net gain of about 120,000 b/d—nearly 1 percent of 1980 output.

Drillers from the Tatar and Bashkir ASSRs, Kuybyshev and Saratov Oblasts, and Belorussian and Ukrainian Republics are temporarily working in West Siberia. The contribution of these expeditionary drillers has risen rapidly, from 244,000 meters drilled in 1977 to over 4 million meters in 1981 [56]. In early 1984, 133 out of the 308 drilling brigades in Tyumen' Oblast were expeditionary brigades [57].

There are several variants of the expeditionary method. In some cases the workers live in their home districts (in the Tatar ASSR, for example), fly to West Siberia to work, living in primitive workers' settlements near the oilfields for 10 to 14 days, and then return home for about two weeks. In other cases, workers live in established West Siberian towns (such as Surgut or Nizhnevartovsk), to which they return between two-week stints in the field. In a third variant, drillers from other areas come to West Siberia for longer periods, residing in an established West Siberian town between work periods; after a 30-to-40-day tour, they return to their homes for extended leave.

The men who form an expeditionary brigade generally train with experienced West Siberian drillers for four to six weeks before working independently. In 1981 the average drilling rate for expeditionary brigades was only 83 percent of that for local West Siberian crews [58]. According to Soviet press reports, equipment supply difficulties and transportation problems are more troublesome for the expeditionary brigades than for the resident West Siberian brigades [59].

The Soviet technical press has debated the merits of the expeditionary method. Most authors see it as a necessary expedient [60]. To accomplish accelerated drilling tasks, the number of West Siberian drilling brigades had to grow rapidly—more rapidly than a

permanent work force could grow. Infrastructure development, particularly housing construction, lags behind the drilling effort. In addition to the time and resources required for infrastructure development, the expense of maintaining a large permanent work force in West Siberia would be enormous. According to Soviet estimates, it costs 17,000 to 20,000 rubles annually to maintain a worker in West Siberia and only 500 to 600 rubles in the European USSR (these savings exclude the costs of transporting workers to and from West Siberia) [61].

Continuing Problems

Presumably the lack of infrastructure—especially roads and transport capabilities—is hampering somewhat the expansion of drilling brigades. In 1980 the Soviets discussed an unusual four-year program for 1980-83 to accelerate rapidly the construction of roads, houses, and transport [62]. Its overall results are not yet clear: it has made substantial progress but is apparently falling behind expectations. The housing construction goal discussed in 1982 is more modest than that discussed in 1980 [63]. Furthermore, according to articles in the press, the lack of roads continues to hamper the development of new fields, and housing shortages are still a problem [64]. Until infrastructural problems are solved, drilling in West Siberia will be handicapped, wherever the drillers come from.

drilling problems at several West Siberian fields continue to be severe, as evidenced by the relatively high share of drilling rigs that are inactive. The percentage of total assembled rigs that were active in selected areas in 1980 and 1982 is shown in table 16.

Table 16
Active Drilling Rigs in Selected West Siberian Oilfields, 1980 and 1982

Percent

	1980	1982
Samotlor	77	72
Agan	83	67
Vakh	78	88
Severo Var'yegan	83	84
Var'yegan	100	40 to 55
Pokachev		60
Ur'yev		83 to 100
Mamontovo		73

The cause of the reduction in rig activity observed in some areas is not clear. Most of the idle sites appeared to have no drill pipe, and continuing complaints in the press about the lack of quality drill pipe confirm the shortages of this critical material [65]. Samotlor is a case in point. It is a well-established field, in which drilling problems cannot be attributed to infrastructure constraints. Even so, at Samotlor between 23 and 28 percent of the rigs were inactive at six separate sightings between 1978 and April 1982. This situation suggests that shortages of drill pipe (and possibly of manpower) are the principal problem. Imagery from late 1983 indicates that the level of rig activity, although still a problem, is improving.

25X1

Appendix C

Drilling Equipment and Technology

The USSR produces most of its own drilling equipment, but it relies on imports to fill specific needs, such as drill pipe, high-pressure blowout preventers, and offshore drilling equipment. Table 17 lists production of drilling rigs, electric drills, and turbodrills—the only types of drilling equipment regularly reported in Soviet production statistics. Table 18 shows the locations of the production plants.

Soviet drilling technology lags behind Western technology. US drilling rigs are about 2.5 times as productive as Soviet rigs. Although much of this productivity problem is caused by organizational and logistic problems endemic in the system, many Western observers say that drilling technology is 10 or more years behind that employed in the West [66]. Others disagree, pointing to Soviet advances in the turbodrill and in arctic drilling [67].

Turbodrills and Electrodrills

In the USSR the turbodrill is used for over 80 percent of total drilling—48 percent of exploration drilling and 87 percent of development drilling [68]. Turbodrills use downhole turbines powered by drilling mud to turn the bit, rather than rotating the entire drill string, as is normally done in the West.[12] The turbodrill has been effective in developing the shallow, hard-rock formations in the Volga-Urals Basin and for directional drilling from the cluster pads in West Siberia. Its use enables drillers to sidestep many problems that would arise with the use of Soviet drill pipe and tool joints, which are of low quality and could not withstand the stresses of rotary drilling operations. Because turbodrilling eliminates torque stress on the drill string, it reduces the amount of time spent retrieving and replacing broken drill pipe.

[12] Drilling mud is a mixture of clay, water, and chemicals pumped into the well for lubrication and to bring rock cuttings to the surface. It also serves to control downhole pressure.

Table 17
USSR: Production of Turbodrills, Electrodrills, and Drilling Rigs, Selected Years

	Turbodrills	Electrodrills	Drilling Rigs
1965	8,439	220	520
1970	6,562	115	480
1971	7,384	114	497
1972	7,694	86	512
1973	8,103	112	516
1974	9,328	104	483
1975	9,780	97	544
1976	9,354	108	511
1977	9,700	96	503
1978	9,016	81	505
1979	8,976	21	473
1980	9,270	NA	521
1981	9,459	NA	541
1982	9,291	NA	558
1985 (estimate)			800

Sources: *Narodnoye khozyaystvo* for 1975, 1979, 1980, 1981, and 1982

25X1

25X1

25X1

25X1

25X1

25X1

25X1

25X1

25X1

25X1

Table 18
Principal Soviet Plants Producing Drilling Equipment, 1984

Type of Equipment	Location of Plant
Turbodrills	Perm' (two plants), Baku
Drill bits	Kuybyshev, Drogobych, Moscow, Poltava, Sarapul, Saratov, Verkhniye-Serginsk, Kiev
Drill pipe and casing	Chelyabinsk, Dneprodzerzhinsk, Nizhnedneprovsk, Rustavi, Sumgait, Taganrog, Zhdanov
Drilling rigs	Sverdlovsk, Verkhnyaya Pyshma, Volgograd
Offshore drilling rigs	Baku, Astrakhan', Vyborg
Miscellaneous drilling equipment	Ashkhabad, Baku (several plants), Kharkhov, Kutaisi

Electric drills, which have a downhole electric motor, were used in 1.6 percent of total Soviet drilling in 1980—down from 2.8 percent in 1970 [69]. The technical difficulties in manufacturing a durable cable to provide electric power for drilling at depths of 2,000 to 3,000 meters are enormous. The Soviets continue to experiment with electrodrills; however, they produced only 21 in 1979, the last year of reported production, suggesting a general disillusionment with the method [70].

According to Soviet forecasts for 1981-90, rotary rigs and low-speed, high-torque turbodrills eventually will make up 70 to 80 percent of the drilling effort [71]. The Soviets have thus far focused on the need to improve the operating characteristics of the turbodrill and to manufacture better drill bits. In recent years they have been working on a program (begun in the 1960s) to reduce the turbine speed of the turbodrill and increase the torque, or pressure of the bit on the rock. Although technical journals have been discussing the low-speed turbodrill since the program began—indicating 20 years without a major breakthrough—Soviet statements continue to emphasize this drill as the key to improving drilling speed [72].

The depth to which wells must be drilled is increasing, however, and we therefore expect the Soviets to turn increasingly to rotary drilling. Indeed, their recent interest in Western equipment for rotary drilling rigs suggests such a shift. This would require a substantial and expensive modernization of their production of high-quality drill pipe.

25X1

Drilling Rigs

The USSR produced drilling rigs of all types used in oil and gas drilling at a rate of about 500 per year in the 1970s; the rate rose to 558 rigs in 1982. The average service life of a Soviet rig is six to 10 years (it is 15 to 20 years for rigs built in the United States).[13] Until recently, nearly all Soviet rigs were built at two plants—the Barrikady plant in Volgograd and the Uralmash plant in Sverdlovsk, with Uralmash producing some 80 percent of the total [73]. A new drilling-rig plant was built in 1981 in Verkhnyaya Pyshma, north of Sverdlovsk. the apparent rig assembly area of the new plant is 70 percent larger than that at Uralmash.

25X1

25X1

25X1

If we assume that the 521 rigs produced in 1980 represented nearly maximum use of capacity at the two older plants, then the new plant could enable the Soviets to increase rig production to about 800 rigs annually. Such a supply should satisfy their requirements at least through 1985. Drilling needs beyond 1985 may require additional plant construction.

25X1
25X1

Drill Pipe

Soviet pipe is generally adequate for drilling shallow wells (less than 2,000 meters) with the turbodrill, which does not subject the drill string to torque. At greater depths, the poor-quality steel used in Soviet drill pipe often fails under the torque required for

[13] Our estimate of the life of a Soviet rig is based on analysis of changes in rig park size and rig production.

25X1

25X1

25X1

rotary drilling, and its inadequacies can be troublesome even with turbodrilling. Problems relating to the quantity and quality of drill pipe and casing produced in domestic plants have been reported frequently by the Soviet press. For example, it cited insufficient quantities as factors in the underfulfillment of West Siberian drilling targets in 1979 and 1980 [74]. The Soviets currently import substantial quantities of drill pipe, and we expect them to continue

Moscow has been negotiating for several years with US and Japanese firms to purchase a turnkey plant for drill pipe and casing, but to date no contract has been signed. In the fall of 1981, the USSR sought bids on a plant to manufacture drill collars and kellys—parts that suffer particular stress—with production capacity sufficient to support 2,000 to 3,000 rotary rigs. No progress has been reported on negotiations for this plant.

Drill Bits

The Soviet Union's annual output of drill bits of all types (for mining as well as for gas and oil drilling) is reported to be about 1 million units [75]. The Soviets have developed natural and synthetic diamond bits and are experimenting with hard alloy and coated bits. Although some improvements have been made in domestic bit design and productivity, Soviet bits have proved to be only about one-fourth to one-tenth as efficient as comparable bits produced in the United States.

In 1978 the Soviets bought a $158 million turnkey drill bit plant from Dresser Industries (a US firm) for installation at Kuybyshev. The plant, which began operating in January 1982, is eventually to produce 100,000 high-quality tungsten-carbide-insert bits per year. At the high speeds of Soviet turbodrills, these new bits should operate for far longer periods than conventional Soviet-made bits. This will reduce downtime for bit replacement, thereby increasing rig productivity and reducing somewhat the requirement for new drilling rigs.

We estimate that the new Kuybyshev plant's 100,000 high-quality bits could improve Soviet drilling by reducing downtime.[14] The plant has experienced enormous startup problems, however. In May 1982, output was only 1.2 percent of planned capacity, and the bits were of low quality.

25X1

the plant was producing at 25X1

over 70 percent capacity by July 1982 and at 80 percent by early 1983. The quality also was improving 25X1 somewhat. The bits were reportedly performing about half as well as the US-manufactured product,

25X1

[14] We estimate that improved bits can make a one-time 5-percent improvement in drilling efficiency. In 1980 Soviet planners expected to raise the average meters drilled per bit from 77.2 to 198.5 between 1980 and 1985—a 160-percent improvement [76]. Given current difficulties, we estimate that this goal may not be reached until 1990. According to a recent Soviet publication, bit changes occupy 10 percent of the total drilling cycle time [77]. A 160-percent improvement in an operation entailing 10 percent of total time would improve total efficiency by almost 6 percent. Because bits are raised for reasons other than bit changes, we estimate that the improvement to be reached by 1990 will be closer to 5 percent.

25X1 25X1 25X1 25X1

Appendix D

Offshore Drilling

Offshore oil production in the USSR is currently concentrated in the Caspian Sea, where several fields are being developed. Their oil output is estimated at 200,000 b/d—about two-thirds of the production in the Azerbaijan SSR.

Exploratory drilling has been under way since 1975 in the waters off Sakhalin Island in a cooperative venture with Japanese firms (SODECO). During 1977-82, 20 wells were drilled and two oilfields with commercial potential were discovered. Oil production will begin as soon as production platforms can be built to withstand the pack ice conditions in winter (probably not before 1987).[15]

Exploration and production are also under way in the Black Sea and the Sea of Azov, but to date only gas has been discovered. The Soviets are increasingly interested in the Arctic offshore areas, particularly the Barents Sea, despite their lack of engineering and technical experience in these forbidding areas. They have purchased drill ships from Finland and have begun discussions with the Norwegians on a cooperative venture in the Barents. The Soviet Union also is working with East Germany and Poland in a joint venture (Petrobaltic) to explore and develop oil resources in the Baltic Sea in the territorial waters of these three countries.

Overall, the USSR plans to increase its offshore drilling in 1985 to 50 percent above the level attained in 1980 [78]. Much of this emphasis was stimulated by geologists' reports that about 70 percent of the Soviet continental shelf is covered by potentially oil-bearing sedimentary rock [79]. Development of this potential is important if the Soviets are to maintain oil production at relatively high levels beyond the late 1980s. Western equipment and technology will be essential for successful development of offshore areas.

Offshore Operations in the 1970s

The Soviets' offshore drilling program is the oldest in the world. Their effort began in the late 1940s in the shallow waters of the Caspian Sea. As oilfields were discovered, development wells were drilled on platforms, which were connected to shore by trestles to facilitate movement of equipment and supplies.

Offshore oil production in the Azerbaijan SSR peaked at a level of 258,000 b/d in 1970, when offshore drilling totaled about 373,000 meters—215,000 meters of development drilling and almost 158,000 meters of exploratory holes [80]. By 1975 offshore fields accounted for 228,000 b/d, or two-thirds of the region's total oil production. The share has remained constant since the mid-1970s, although total oil production in Azerbaijan has been declining. In 1980 the Soviets drilled 175,000 meters of development wells in the Caspian Sea. The average depth of the exploratory wells reached 5,250 meters in that year, as the new mobile offshore drilling rigs allowed the Soviets to investigate deeper oil deposits [81].

In 1966 the USSR ordered its first jack-up mobile drilling rig from the Netherlands.[16] The unit was shipped in 1967, was rigged out in Baku, and began operations in the Caspian Sea in the fall of 1968. Since that time the Soviets have built six jack-up units—five for use in the Caspian Sea and one in the Black Sea [82].

In the summer of 1976, the USSR signed a contract with a US firm, Armco International, for a semisubmersible offshore drilling unit. The unit was built in the shipyards of Rauma Repola, a Finnish company.

[16] Jack-up drilling rigs are platforms with three or four legs, which are lowered to the sea bottom to raise the platform above the water. Semisubmersible rigs, on the other hand, are partly submerged; they float on the water and are anchored in place.

25X1

25X1

It was completed in late 1977 and transported in modules via inland waterways to Baku, where it was assembled and rigged out. It finally began drilling operations in the Caspian Sea in September 1981, some five years after construction had begun.

In September 1978 the Soviets centralized offshore exploration and development activities under a new chief directorate (Gipromorneftegaz) in the Ministry of the Gas Industry. Their purpose was to speed up technological progress and to increase exploratory drilling work in offshore areas. The Soviets expected to buy offshore drilling equipment—jack-ups, semisubmersibles, and drill ships—from foreign suppliers for only a short time, until they could produce such items domestically [83]. When Gipromorneftegaz was set up, only one yard (at Astrakhan') was capable of constructing mobile offshore jack-ups, and its output could not meet the needs of the oil industry of the Caspian Sea area alone [84].

The Soviets have made significant strides in offshore drilling work but have fallen far short of their original goals. They intended to have 10 jack-up units in operation in the Caspian Sea and Black Sea by 1980, but had only four. The acquisition of Western offshore equipment and technology was delayed by prolonged discussions and negotiations.

Offshore Prospects for the 1980s

The USSR plans to concentrate offshore exploratory drilling for the next few years in the Caspian Sea, offshore Sakhalin, and in the Barents Sea. In 1980 the Soviets signed a $110 million contract with a French firm, ETPM, to construct fabrication yards at Astrakhan' and Baku for producing mobile offshore drilling units [85]. The first Soviet-built semisubmersible unit—Shelf 1—was completed in 1981 and was placed in operation early in 1982 at an offshore field in the Caspian Sea in water 85 meters deep [86]. Shelf 2 is also operative, and a third semisubmersible rig is under construction. As of mid-1982 the USSR had nine mobile offshore drilling rigs in operation—seven jack-ups and two semisubmersibles. Two additional semisubmersible units are under construction at Vyborg, and eight more are to be built at Astrakhan' and Baku to support exploratory drilling work in the Caspian Sea during the 1980s.

The director of Gipromorneftegaz, Yu. V. Zaytsev, has said the offshore industry must create a supply and equipment base and must make technical improvements in equipment for conducting exploration and development drilling and for the transport of oil and gas from sea to shore [87]. The industry should:

- Increase by 150 percent the number of mobile offshore drilling rigs.
- Acquire equipment capable of drilling to 6,500 meters.
- Produce double-deck fixed platforms for multiple (30 to 50) wells.
- Solve the problems of developing the petroleum resources of the continental shelf under ice and in severe weather.
- Train the personnel needed for offshore operations.

25X1

25X1

In the long run, the Soviets' handling of offshore areas will be an important determinant of the future of the oil industry. Their drilling goals for the 1980s will be difficult to achieve. The level of technical competence and engineering expertise in offshore operations in the USSR lags far behind that in the West, and development in arctic regions probably will progress more slowly than the Soviets anticipate. Much will depend on the amount of Western equipment they choose to import and the extent to which they embark on cooperative ventures with Western firms.

25X1

25X1

Barents Sea Prospects

During the summers of 1982 and 1983, two Soviet drillships did exploratory drilling in the Barents Sea. The results of this drilling effort are unknown—but in 1983 the USSR signed an agreement with a consortium of seven Norwegian firms to provide a general work plan for exploration and development of oil and gas deposits in the Barents Sea. A $135,000 study has been completed, detailing the technical assistance the USSR will require to explore an area covering about one-third of the central Barents Sea area.

25X1

25X1

25X1

Thus far the Soviets are reported to have mapped about 15 to 20 geologic structures, and they are rumored to have discovered a gas pocket. This pocket could be either the top of an oilfield or a gas discovery. They probably will be much more interested in oil, having already discovered large undeveloped gas reserves onshore.

25X1

The Soviets clearly view the development of any Barents Sea hydrocarbons as a long-term project. Any oil found there is not likely to be available—even with significant Western help—until well into the 1990s.

25X1

a Barents Sea development project will take 10 to 15 years. The pace of development will depend on conditions the Soviets encounter in new onshore areas, particularly in west Siberia. The eventual cost of developing a large discovery—the size of that at Prudhoe Bay on Alaska's northern coast—could easily amount to $25 billion, depending on its location.

25X1

Appendix E

Drilling Investment as a Basis for Forecasting Oil Industry Investment

In an effort to develop a more precise estimate of Soviet oil industry investment, we used investment in drilling as an indicator for total investment. Statistical analysis of the data on drilling meterage and drilling costs can be correlated with oil industry investment. Then, assuming no significant shift in the structure of the investment, we can use our drilling projections to forecast investment in the oil industry.

Data on drilling costs are available for 1970-79 (see table 8 in the text). We estimated future drilling costs by extrapolating the 10-year 1970-79 trend as a lower bound and extrapolating the accelerating costs of the three years 1977-79 as a higher bound. We expect drilling costs to continue to increase, for several reasons:

- The increasing depth and pressure of newer deposits.
- The rising share of expensive offshore drilling in total drilling.
- The rising share of drilling in small, isolated oilfields, where infrastructural shortcomings make drilling less efficient.

We also expect, however, that drilling productivity gains will to some extent moderate the impact of cost increases, placing drilling costs near the center of our estimate.

Soviet statements indicate that drilling outlays represent between 40 and 50 percent of oil industry investment. Our comparison of 1970-82 estimated drilling costs with Soviet oil industry investment indicates that drilling outlays averaged 44.5 percent of total investment. We expect all oil industry activities to increase rapidly during the 1980s—not only drilling, but such others as fluid lift, infrastructure, well repair, and enhanced oil recovery. We therefore see no reason for the share of drilling in total investment to change significantly.

Estimates of Investment

Combining our estimates of drilling and drilling costs with the assumption that these costs represent 45 percent of investment, we estimate overall oil industry investment as follows (billion rubles):

	1985	1990
Low drilling scenario	11.7	16.6
High drilling scenario	12.4	23.5

25X1

25X1

Using econometric techniques, we developed a multiple regression model that explained past trends well and was statistically significant. When this model is projected forward, it yields forecasts within 2 percent of the first estimates (billion rubles):

	1985	1990
Low drilling scenario	11.5	16.5
High drilling scenario	12.2	23.3

These estimates are of course only the center of a wider range, because drilling cost estimates vary widely. Incorporating the full range of drilling cost estimates from table 8 yields a range of ±10 percent around these midpoints.

25X1

Thus, for the low drilling scenario, 1990 investment requirements will need to be double the 1982 level of 8.7 billion rubles. Under the high drilling scenario, they will need to be nearly triple.

25X1

Regression Equations

Several regression equations were used to estimate investment requirements. The first simply presents investment as a function of total drilling outlays:

$$I = \underset{(70.73)}{2.25}\ ((DD * DC) + (XD * XC)) \qquad (1)$$

25X1

where DD is development drilling, DC is development drilling cost, XD is exploratory drilling, and XC is exploratory drilling cost.

25X1

25X1

This equation has good explanatory power (corrected $r^2 = 0.983$) and confirms Soviet statements about drilling outlays accounting for 40 to 50 percent of oil industry investment. However, a low Durbin-Watson statistic (0.40) indicates strong autocorrelation problems. (An intercept term was found to be statistically insignificant in this equation and those that follow.)

Oil industry development and exploration drilling have followed different trends since 1970 (see figure 1 in text). Combining drilling costs as in equation 1 is therefore an oversimplification. For breaking drilling costs into their exploration and development components, we used a second equation:

$$I = \underset{(20.08)}{2.42\,(DD * DC)} + \underset{(9.82)}{1.96\,(XD * XC)} \qquad (2)$$

Both coefficients are statistically significant; the explanatory power is high (corrected $r^2 = 0.985$), but autocorrelation is still a serious problem (Durbin-Watson = 0.56).

25X1

The first equation overestimated investment in all years except 1977-81. The second equation had the same pattern, but overestimated in all years except 1976-80. This difference suggests that something occurred in the later 1970s that is not captured in the regression variables. We know from official Soviet statistics in the USSR's annual statistical abstract, *Narodnoye Khozyaystvo*, that growth of investment in the oil industry accelerated in the years 1977-81 and slowed in 1982.

25X1

Assuming that during the 1977-81 period there was a policy shift in investment, we can use a dummy variable to represent such a change, setting the variable equal to 1 in 1977-81 and to 0 in all other years. The equation is then:

$$I = \underset{(35.78)}{2.28\,(DD * DC)} + \underset{(20.07)}{1.96\,(XD * XC)} + \underset{(6.00)}{(4.68) \times 10^8)\,D,} \qquad (3)$$

where D is the dummy variable. The coefficient of the dummy variable indicates that during 1977-81 there was a temporary increase in the proportion of non-drilling investment. The explanatory power increased (corrected $r^2 = 0.996$), all the variables are significant, and autocorrelation is not a problem (Durbin-Watson = 2.11). Experimenting with other combinations of the dummy variable indicated that 1977-81 were the critical years, as we would expect.

25X1
25X1

Using the third equation to forecast investment, we obtained the results presented in the text. These are very similar to the results obtained by using the simple guideline that drilling costs represent 45 percent of total investment.

25X1

25X1

Next 2 Page(s) In Document Denied

Major Soviet Petroleum Deposits and Oil Pipelines

25X1

25X1